Center Innovation Fund: AFRC CIF

Distributed Aerostructural Sensing and Control

Completed Technology Project (2013 - 2016)

Project Introduction

Armstrong researchers are investigating ways to increase aircraft maneuverability, safety, and fuel efficiency by the application of networks of smart sensors distributed across an aircraft. This "fly by feel" concept could enable a vehicle to autonomously react to changes in aerodynamic and structural conditions through the use of distributed pliable membrane sensors that obtain real-time information and convert it into aerodynamic information that can be used for adaptive flight control. In comparison with conventional sensing technologies, which measure aerodynamic parameters from an aircraft's fuselage only, these smart sensors enable localized measurements at nearly any surface on an aircraft structure. For example, hot film sensors could be placed at wing transition points to measure shear stress or along the leading edge of a wing to measure velocity and angle of attack. The ultimate goal is to feed real-time sensor information into a control scheme such that the aircraft can autonomously control the position of a surface appropriately for active aeroelastic wing control. Work to date: The team is conducting sensing and analysis work with hot film sensors: 1) wind tunnel tests at Texas A&M University on a wing outfitted with hot film sensors and subjected to wind gusts 2) hot film sensors on the leading edge of a Gulfstream III wing to measure transitions between the leading edge and the control flap 3) wind tunnel tests on a wing section of the X56 aircraft 4) hot film sensors installed on the leading edge of an F18 aircraft. Looking ahead: Next steps involve more investigative work with the X56 aircraft, specifically hot film sensors combined with fiber optic strain sensing and associated data fusion algorithms to address distributed sensing and control applications. Partners: Texas A&M University for wind tunnel tests, California Institute of Technology for computational studies augmented with Illinois Institute of Technology wind tunnel tests, University of Minnesota Aerospace Engineering and Mechanics for distributed aeroelastic control Benefits Autonomous: Could enable real-time performance-based measurements Accurate: Could permit revolutionary capabilities across a wide speed range, including but not limited to shorter takeoff and landing even to near-stall conditions, safe and reliable supersonic operation, larger passenger and cargo capacity over increased range Improved safety: Provides localized data, enabling engineers to be more confident that design specifications offer appropriate safety margins Certifiable performance and stability guarantees Aerostructural efficiency Applications Aircraft testing and design Vortex interaction for formation flying and increased landing density at airports Improved drag reduction and increased lift performance Active aeroelastic control of flexible structures

Anticipated Benefits

Distributed Aerostructural Sensing and Control F18 Flight Test

Table of Contents

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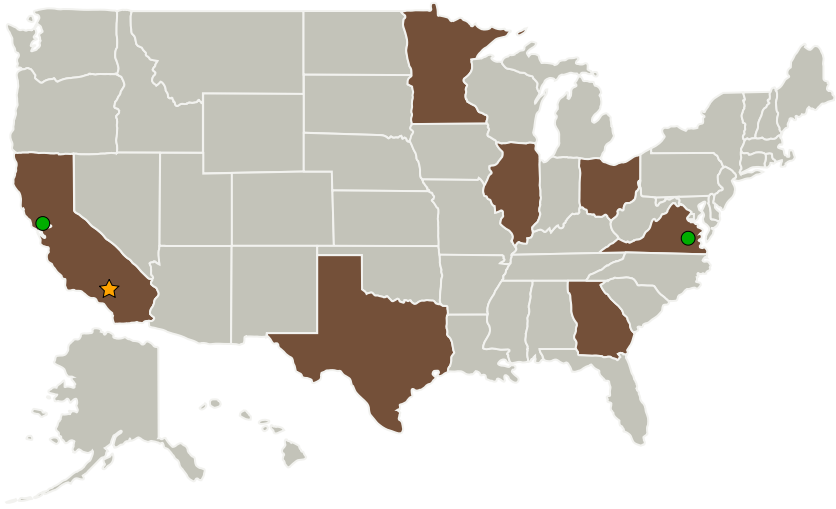
- **Autonomous**: Could enable real-time performance-based measurements
- **Accurate**: Could permit revolutionary capabilities across a wide speed range, including but not limited to shorter takeoff and landing even to near-stall conditions, safe and reliable supersonic operation, larger passenger and cargo capacity over increased range
- **Improved safety**: Provides localized data, enabling engineers to be more confident that design specifications offer appropriate safety margins
- **Certifiable performance and stability guarantees**
- **Aerostructural efficiency**

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Armstrong Flight Research Center (AFRC)

Responsible Program:

Center Innovation Fund: AFRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

David F Voracek

Principal Investigator:

Martin J Brenner

Co-Investigators:

Peter Seiler
Tom Strganac
Nicholas R Alley
Dave Williams
Tim Colonius
Arun Mangalam

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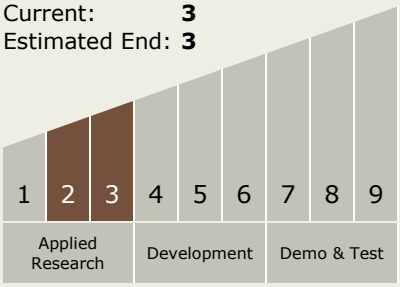
Organizations Performing Work	Role	Type	Location
★Armstrong Flight Research Center(AFRC)	Lead Organization	NASA Center	Edwards, California
Air Force Research Laboratory(AFRL)	Supporting Organization	US Government	Notre Dame, Indiana
●Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California
Area-I, Inc.	Supporting Organization	Industry	Kennesaw, Georgia
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California
Illinois Institute of Technology	Supporting Organization	Academia	Chicago, Illinois
●Langley Research Center(LaRC)	Supporting Organization	NASA Center	Hampton, Virginia
Tao Systems	Supporting Organization	Industry Small Disadvantaged Business (SDB)	
Texas A & M University-College Station(Texas A&M)	Supporting Organization	Academia	College Station, Texas
University of Minnesota-Twin Cities	Supporting Organization	Academia	Minneapolis, Minnesota
Virginia Polytechnic Institute and State University(VA Tech)	Supporting Organization	Academia	Blacksburg, Virginia

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX15 Flight Vehicle Systems
  - TX15.2 Flight Mechanics
    - TX15.2.3 Flight Mechanics Testing and Flight Operations

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Co-Funding Partners	Type	Location
Air Force Research Laboratory(AFRL)	US Government	Notre Dame, Indiana
Area-I, Inc.	Industry	Kennesaw, Georgia
California Institute of Technology(CalTech)	Academia	Pasadena, California
Illinois Institute of Technology	Academia	Chicago, Illinois
Tao Systems	Industry Small Disadvantaged Business (SDB)	
Texas A & M University-College Station(Texas A&M)	Academia	College Station, Texas
Virginia Polytechnic Institute and State University(VA Tech)	Academia	Blacksburg, Virginia

Primary U.S. Work Locations	
California	Georgia
Illinois	Minnesota
Ohio	Texas
Virginia	

Images

Distributed Aerostructural Sensing and Control F18 Flight Test
Distributed Aerostructural Sensing and Control F18 Flight Test *(https://techport.nasa.gov/image/6592)*